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(71) Applicant *(for all designated States except US)*: NET INSIGHT AB [SE/SE]; Ingenjörsvägen 3, S-117 43 Stockholm (SE).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*:   LINDGREN, Per [SE/SE]; Maria Prästgårdsgatan 12, S-118 52 Stockholm (SE). BOHM, Christer [SE/SE]; S:t Paulsgatan 28A, S-118 48 Stockholm (SE). GAUFFIN, Lars [SE/SE]; Orrstigen 18, S-144 44 Rönninge (SE).

(74) Agent: AWAPATENT AB; P.O. Box 45086, S-104 30 Stockholm (SE).

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(54) Title: BITSTREAM MANAGEMENT

(57) Abstract

The present invention relates to the transferring of data via a shared medium between nodes in a time multiplexed network, wherein said data is transferred in time slots in one or more bitstreams. To obtain an efficient network, the synchronisation of parallel bitstreams is of great importance. A high degree of utility is provided by time slot reuse. The above-mentioned characteristics are obtained by regenerating each bitstream as a whole in a node. This also solves problems with dispersion, attenuation, clock gap and clock extraction. The invention is preferably provided using WDM in a DTM network.

BITSTREAM MANAGEMENT

Field of invention

The present invention relates to methods, devices
and systems for more efficient use and synchronisation of
parallel bitstreams in circuit switched time multiplexed
5   networks, wherein data are transferred between nodes via
a shared medium (e.g. a network with a bus or ring
topology) and multi access, preferably a network of the
DTM (Dynamic Synchronous Transfer Mode) type.

Technical Background and Prior Art

10   New communication networks and protocols are being
developed continuously by the telecommunication industry
and the academic world. The technology is ever changing,
and new results and discoveries are important to software
15   application developers, whose task it is to integrate
real time sound communication, real time video communica-
tion and asynchronous communication services. The applic-
ations are provided on a wide spectrum of network termi-
nals. The terminals may be almost any electronic devices,
20   including small cellular phones, television sets, multi-
media workstations or supercomputers worth millions of
dollars. The terminal hosts differ from each other by
several magnitudes regarding the demands on processor
capacity and service levels.

25   The two basic types of network are connection-
oriented, circuit switched networks, which are used e.g.
in conventional telephony, and connectionless, packet
switched networks, which may be exemplified by the
Internet.

30   When a circuit switched network is used for data
communication, the connections are left open between
bursts of information, which leads to waste of resources.
This situation arrises as a result of the connect and
disconnect operations being time consuming compared to
35   the dynamic variations of the user's needs. Another

source of waste of resources in circuit switched networks
is the limitation inherent in the fact that it is only
possible to have symmetrical duplex channels, which means
that only half the resources allocated to the connection
5   are used when the information flow goes in only one
direction.

A packet switched network, on the other hand, lacks
means for reserving resources, and has to add information
to the header of each message before sending it. More-
10   over, delays in a packet switched network cannot be pre-
dicted with adequate accuracy, and some packets may even
be lost during transfer because of buffer barriers, so
called "buffer overflow", or because of destroyed infor-
mation in the header of the packet. These two latter
15   aspects make it difficult to support real time services
in a packet switched network.

In order to address the above mentioned problem, the
communication industry is focusing on the development of
so called ATM systems (Asynchronous Transfer Mode). The
20   CCITT (International Telegraph and Telephone Consultative
Committee) has also accepted ATM as a standard in B-ISDN
(Broadband - Integrated Services Digital Network). ATM is
connection-oriented and establishes a channel, in similar
to a circuit switched network, but uses small packets of
25   fixed size, which are called cells, for information
transfer. The packet oriented nature of the ATM system
requires that the network provides mechanisms such as
buffer resources and link managers in order to be able to
guarantee real time demands on a connection.

30   A new solution, DTM - Dynamic synchronous Transfer
Mode (See C. Bohm, P. Lindgren, L. Ramfelt and P. Sjödin,
"The DTM Gigabit Network", Journal of High Speed Net-
works, 3(2), 109-126, 1994 and L. Gauffin, L. Håkansson
and B, Pehrson, "Multi-gigabit networking based on DTM",
35   Computer Networks and ISDN Systems, 24(2), 119-139, April
1992) aims to meet the demands on real time characteris-
tics and focuses on circuit switched networks and there-

fore has to address the typical problems of circuit switched networks described above. A new protocol for managing a shared medium, especially an optical wave conductor through which at least some nodes communicate
5   on a shared wavelength, is also used, which means that the problems of controlling shared media also have to be taken into consideration.

DTM is a circuit switched network designed for use in public networks as well as in local area networks
10   (LAN). DTM uses channels as communication abstraction. These channels differ from telephony circuits in different ways. First, the connection delay is so short that resources can be allocated or disallocated dynamically depending on the user's needs. Second, the channels are
15   of the simplex type and therefore minimise extra costs. Third, multiple bitrates are provided, which make it possible to support large variations of the user's capacity requirements. Finally, the channels are multicast, which permits more than one end destination.
20   Circuit switched DTM channels show many advantageous characteristics. There is no transfer of control information after channel establishment, which results in a high degree of utilisation of the network resources when transferring large amounts of data. The support for
25   real-time traffic is built in and there is no need for policing or flow management within the network. The transferring delay is small, and there is no possibility of loss of data as a consequence of buffer overflow as in ATM. The bit error frequency depends on the underlying
30   link technologies, and the switching is fast and simple as a result of the strict reservation of resources at channel connection. DTM shows good characteristics within fields where traditional circuit switched networks fall short; dynamic allocation of resources, channel set-up
35   delays, and as networks with a shared medium.

The basic topology of a DTM network is preferably a bus with two unidirectional optical fibres connecting all

nodes, but it can also be realised by any other kind of
structure, for instance, a hub or ring structure. The DTM
medium access protocol is a time-division multiplexing
scheme. Moreover, wavelength division multiplexing can be
5   used on a bus in the form of an optical fibre in order to
increase the network capacity. The bandwidth of the bus
is divided into 125 µs cycles, which in turn are divided
into 64-bit time slots. The number of slots in a cycle
thus depends on the networks bitrate. The slots are
10   divided into two groups, control slots and data slots.
Control slots are generally, but not necessarily, static
and used to carry messages for the network's internal
operation. The data slots are used for the transfer of
user data.
15   In each network node there is a node controller,
which controls the access to data slots and performs
network management operations.
          Control slots are used exclusively for messages
between node controllers. Each node controller has write
20   permission to at least one control slot in each cycle,
which it uses to broadcast control messages to other
nodes. Here, broadcast refers to sending information to
all downstream nodes on a bus, as the transmission medium
is unidirectional. Since write access to control slots is
25   exclusive, the node controller always has access to its
control slots regardless of other nodes and network load.
          In order to achieve large data transmission rates,
there are two ways of approach, either to increase the
frequency, e.g. the number of transferred bits per
30   second, or to use parallel transmissions of data. Since
the cost of electronic equipment increases rapidly with
increasing data reception rates, there is an evident
advantage to using parallel transmissions of data in
order to achieve very large data transmission rates.
35   Furthermore, state-of-the-art technology for achieving
the optimal rate of transferred bits per second may of

course be used, but still the overall transmission rate
will be multiplied by parallel transmission of data.

To transfer data in parallel streams, two kinds of
parallel systems may be used, among other, with the
5   technology of today; bitstreams may be transferred in
physically separated carriers, so called SDM (Space
Divison Multiplexing) or a carrier in which different
bitstreams are sent on different wavelengths or
frequencies may be used, so called WDM (Wavelength
10   Division Multiplexing. Of course, a combination of these
two techniques may also be used in order to obtain
optimal use of the network. In this context, the term
"parallel bitstreams" refers to both SDM and WDM.

A number of advantages of using DTM in connection
15   with parallel data transmission can be identified. DTM
uses a shared medium with separated control and data
channels, which frees a node from the necessity of
supervising all bitstreams in order to identify possible
flags or headers. DTM is connection-oriented and uses TDM
20   (Time Division Multiplexing) channels, which means that
the node knows where and when data is to be read or
written. Through TDM, several connections may be made on
a single bitstream, which results in high channel resolu-
tion. Most WDM structures use one wavelength as the
25   lowest resolution rate.

All of the above make DTM especially suitable for
parallel data transmission. There are, however, no
obstacles to using the methods proposed in this invention
for other types of time multiplexed protocols.
30   In the broadband networks of today and tomorrow, the
majority of the nodes will be broadband receivers, but
narrowband senders, such as in Video on Demand
applications. The greatest need for most of the nodes
should therefore be for the ability to receive large
35   amounts of data in a short period of time, rather than
the ability to send large amounts of data.

The proposed inventions is not limited to this kind

of node, but is especially suitable to handle the type of applications where the reception of data is broadband compared to the sending of data.

Furthermore, there exists a number of larger and
5   smaller problems associated with the use of parallel bitstreams. One of these problems arrises when the recipient has to change bitstreams in order to read new data. Before the data can be read, the recipient has to synchronise its clock to the new bitstream. This may take
10   some time, especially if the recipient has to synchronise to other than the bit clock, for instance to time slots and frames. Another problem is that time slots in the different parallel bitstreams may drift in relation to each other. If a node then is to read time slots from
15   different parallel bitstreams, there is a risk that they may overlap and cause a conflict if the node only has the ability to read from one bitstream at a time.

A difficult problem when transferring data optically is dispersion, i.e. the effect of the light having diffe-
20   rent propagation velocity at different wavelengths, which means that two wavelengths, which are synchronised when sending, not necessarily are synchronised when receiving.

Complexity increases if optical bypass is used on a shared medium. Optical bypass is advantageous for several
25   reasons. Also, if a node error occurs, data that is optically bypassed will not be affected by the node error and may pass the node. This makes it possible for other nodes that communicate on bypassed wavelengths to continue communicating regardless of the node error.

30   When transmitters are to share a wavelength using optical bypass, there is a number of areas to be taken into consideration. Data having its origin at different distances from the receiver will show different attenua-tion, which may cause difficulties when reading the data.
35   Since data is generated in different nodes having diffe-rent local clocks, gaps between clocks may occur, and since different local lasers are used, which may show

small differences in wavelength, there may arrise so
called intra wavelength dispersion, which means that
closely spaced time slots may overlap and slide into each
other. Different bitstreams generated with different

5   clocks may also drift in relation to each other, which
may lead to so called "slip" problems when switching/-
rerouting, or to so-called "slot contention", i.e.
collisions occurring when the receiver is forced to
receive several time slots at different wavelengths at

10 the same time.

Prior, attepmts have been made to solve some of the
above problems by the introduction of the so-called
"guard bands" between messages on one or several
bitstreams or wavelengths, i.e. time slots containing

15 data have been separated from each other by empty time
slots in order to allow some drift without the risk of
overlapping of bitstreams or time slots.

In the First IEEE International Workshop on
Broadband Switching Systems, April 1995 in Poland, page

20 182, wavelength reuse in systems with parallel bitstreams
in an optical WDM network is described.

The Swedich patent SE 460 750 describes a telecom-
munications system in which time multiplexed speech and
data information is transmitted over buses in a matrix

25 network.

The Swedich patent SE 468 495 describes a method and
a device for synchronisation of two or more time
multiplexed communication networks.

30 Summary of the invention

The presesnt invention addresses problems described
above and in the following, for instance problems with
bitstreams drifting in relation to each other, problems
with dispersion and especially intra wavelength

35 dispersion, problems with different attenuation of data
emanating from different nodes, problems with gaps

between clocks and problems with recovering the clock from the incoming data.

Equipment to be sold for home use, for instance TV-sets, videos, computers etc, is very price sensitive. The manufacturing of this equipment for as attractive a price as possible is a very important factor of competition in the home electronics sector. For nodes to be used in broadband applications the problems becomes extra large, since top-of-the-art technology with large demands on hardware and software must be used for these nodes. The problem of high costs for broadband nodes can partly be solved by giving the node the possibility of reading data from several bitstreams but transmitting data on only one or a few bitstreams.

Yet another problem is how to derive the clock. The solution uses a plesiosynchronous mechanism for providing bit synchronisation, which means that the clock is derived from the bitstream. This means that the bitstream must have a given number of clock edges in order to trigger PLL (Phase Locked Loop) and a relatively high DC stability. This can be achieved by the coding of data and by sending the clock edges in empty time slots. If a pure draining mechanism is used with optical bypass, an empty time slot must not contain "light" when a sender is adding data to a time slot. In order to solve this problem, a very fast optical 2:1 multiplexor, able to switch on separate bits, must be used. This is techni-cally extremely difficult and also very costly.

An object of the invention is therefore to effici-ently use parallel bitstreams, e.g. WDM or SDM or a combination thereof, without the occurence of problems with attenuation, clock gaps, clock derivation, drifting or dispersion, and at the same time to achieve a cost-effective solution.

Another object of the invention is to improve the communication capacity of a time multiplexed network, wherein the time is divided into cycles, which in turn

are subdivided into time slots for the transmission of
data and control information, and wherein the network
uses a shared medium with multi-access.

According to one aspect of the invention, these
5   problems are solved by all the data in a bitstream being
regenerated in one and the same node, wherein the
incoming bitstream is stopped from further propagation
along the shared medium, and is instead completely
regenerated in the node. Thus the node is prevented from
10   writing data in the wrong time slots, which may be due to
that parts of the bitstream are not synchronised with the
write function of the node.

According to another aspect of the invention, an
improved management of the network is achived by a master
15   node providing a trigger bitstream with synchronisation
pattern. Slave nodes, each being responsible for the
synchronisation of a respective bitstream, synchronise
their bit clock to the trigger bitstream and then
synchronise the starting point or a frame, in a bit
20   stream associated with the slave node, to the start of a
frame in the trigger bitstream.

The method of synchronisation may also be used when
each node in a network is transmitting on a separate
bitstream, but is reading from several bitstreams.
25   DTM thus allows an advantageous method of synchro-
nisation, which allows bitstreams to be processed
independently, which thus reduces or solves the above
mentioned problems.

Synchronisation of parallel bitstreams is very
30   important in order to achieve an efficient network. A
master node is appointed to the network and a trigger
bitstream is associated to the master node. The master
node decides the frame rate in the network by primarily
adding to each cycle a starting pattern in the beginning
35   and a number of filling slots at the end. The filling
slots function to absorb differences in clock frequency
of different bitstreams. Moreover, a number of slave

nodes are chosen, and one or more bitstreams are
associated to each slave node. Each slave node has to be
able to write in its associated bitstreams. The speed of
the bitstream associated to the slave node should be a
5   multiple of the speed of the trigger bitstream. The slave
node listens to the bitstream of the master node, or to
the bitstream of another slave node synchronised to the
master node, and synchronises its own bitclock thereto.
The slave node preferably adds a similar starting pattern
10   and filling slots to its bitstream, in a similar way as
the master node added starting patterns and filling slots
to the trigger bitstream, and synchronises the start of a
frame in its associated bitstream to the start of a frame
on the trigger bitstream. Thus all parallel bitstreams in
15   the network are synchronised.

        Furthermore, the communication between the nodes
connected to the bus can be of different types, e.g.
local communication or remote communication. The DTM
cycles travel along the entire bus, which, for local
20   communication, may result in inefficient use of the
network resources, since only nodes on one segment use
the communication resources.

        According to yet another aspect of the invention,
further possibilities are provided by reuse of time
25   slots. Hence, according to the invention, several users
may use the same bitstream by time slot reuse.

        According to the invention, wavelengths are reused
between different clusters of nodes by the use of an
optical filter for terminating a wavelength. The clusters
30   may be rearranged dynamically during network operation
according to the current network traffic pattern. The
configuration of the clusters are controlled by the node
controllers, which use status information, sent from the
nodes connected to the bus, in order to determine how the
35   clusters should be configured.

        Between each cluster there is a filtering means
provided to the bitstreams which are to utilise time slot

reuse. The filtering means prevents further transmitting
of the bitstream downstream. Within each separate cluster
the same bitstream can then be used for communication
between nodes situated within the cluster. For the commu-
5   nication between different clusters, the node representa-
tive is used as a relay for the transmission of logical
channels.

Time slot reuse is thus utilised by arranging groups
of nodes into clusters, and to each cluster assigning a
10   node representative that communicates with other node
representatives. By also introducing node representatives
within a cluster of nodes, the setup of other nodes
within a cluster is made easier. The node representative
is responsible for all long distance communication, on a
15   separate bitstream.

The principles of time slot reuse and the use of
clusters, synchronisation and regeneration can, according
to the invention, is preferably combined in order to
achieve the desired functionality.

20   Preferably, the most upstream provided node in a
cluster (the cluster master node) starts the cycle on the
cluster wavelength. If the master node of the cluster is
the most upstream node on the entire bus, it is prefer-
ably advantageously used as a reference for the starting
25   of cycles on the bus. Other cluster master nodes can
start cycles that are synchronised to the most upstream
node. They may also start cycles that are not synchro-
nised to other cycles. If the network traffic is to be
switched/rerouted between different clusters or wave-
30   lengths, the bitstream cycles for different clusters and
and wavelengths are preferably synchronised.

According to an embodiment of the invention, a node
receives several parallel bitstreams, which are
transmitted by one or several carriers, for instance an
35   optical fibre that transmits two or more bitstreams on
two or more respective wavelengths. One or some of these
bitstreams is, according to an earlier agreement between

the nodes in the network, the bitstream(s) in which the
node uses one or more time slots to communicate with
other nodes downstream, let us denote this or these
bitstreams B1. B1 is separated from the other bitstreams

5   B2 in a first means and is directed into the node. The
first means is also responsible for stopping B1 from
further transmission along the carrier, i.e. the shared
medium. When B1 reaches the node, the time slots can be
read, and a modified bitstream B1' is obtained by the

10   node writing data into time slots used according to a
previous arrangement. The other bitstreams B2 can be
directed into a reading device that allows the node to
read data from these bitstreams without essentially
affecting them. B1' is then regenerated as a whole for

15   further trnasmission downstream alonng the carrier.
        An advantage to these arrangements is that all the
data in a specific bitstream is generated by one and the
same node, which prevents intra wavelength dispersion,
clock gaps and problems with moderation.

20   Another advantage is that clock edges can be added
to empty time slots in order to guarantee that for
instance a PLL unit can quickly extract the clock.
        Yet another advantage is the possibility of using
time slot reuse. The advantage of using node representa-

25   tives is that nodes of a simpler construction, for
instance including cost-effective low effect or multimode
lasers can be used in the nodes in the cluster that are
not node representatives.
        Another advantage is that transmitters are required

30   only for the bitstreams that the node is communicating
with downstreams. A minimised number of transmitters
result in reduced costs and thus a less expensive
product.
        An advantage of the synchronisation is that the

35   above mentioned problems of "slot congestion" and "switch
slip" are solved, and that a node thus can read or
otherwise use two parallel bitstreams without running the

risk of overlap of information, which is not as easily
achieved without synchronisation according to this
invention.

Exemplifying embodiments of the invention will now
5   be described with references to the accompanying
drawings.

Brief descriptions of the drawings:

Fig. 1 shows an example of a DTM system according to
10   a preferred embodiment of the invention.

Fig. 2 shows regeneration of bitstreams according to
an embodiment of the invention.

Fig. 3 shows an example of table management in a
node when regenerating bitstreams according to the
15   invention.

Fig. 4 shows yet another embodiment of the inven-
tion.

Fig. 5 shows a frame with parallel bitstreams.

Fig. 6 shows time slot reuse with cluster represen-
20   tatives.

Fig. 7 shows a schematic representation of an
embodiment of the invention.

Fig. 8 schematically shows synchronisation according
to an embodiment of the invention.
25   Fig. 9 schematically shows synchronisation according
to another embodiment of the invention.

Detailed description of exemplifying embodiments

First, a protocol of the DTM type will be described
30   as an example of a time multiplexed network with refe-
rence to Fig. 1. The basic topology for a DTM network is
based on a shared medium, e.g. a bus or a ring. In the
description, a bus topology will be used. The bus may
consist of two unidirectional optical fibres, one in each
35   direction, which connect all nodes to each other. Several
buses with different speeds can be connected to form an
arbitrary multistage network. Typically, the buses will

be connected to form a two-dimensional rectangular mesh. A node at the connection between two buses synchronously switches data between the two buses. This allows for rapid switching with constant delay through the node. On
5   each unidirectional fibre of the bus, several wavelengths can be used for the transmission of data, which increases the network capacity.

       The DTM protocol uses a time multiplexing scheme to organise the data on the bus, called DTM medium access
10   control (DTM MAC). As shown in Fig. 1, the bandwidth of the bus is divided into 125 μs cycles, which in turn are subdivided into 64 bit time slots. The number of time slots in a cycle thus depends on the bit rate of the wavelength; for example, there are approximately 12500
15   time slots per cycle on a wavelength of 6.4 Gbit per second.

       Fig. 2 schematically shown an embodiment of the invention wherein a first optical fibre is denoted 1, a first WDM coupler is denoted 2, and a first 1x2 coupler
20   is denoted 3. On the first optical fibre 1, two different wavelengths L1 and L2 are carried, which are used to transmit two bitstreams B1 and B2. B1 is the bitstream that is used by the node for downstream communication. In the first WDM coupler 2, the two wavelengths L1 and L2
25   are separated, and L1, which is used to transmit B1, is transmitted on a second optical fibre 4 to a first optical/electrical converter 5. From the first converter 5, the bitstream is transmitted electrically further into the node (schematically shown as a downward pointing
30   arrow from the converter 5) wherein data can be read and later written (the upward pointing arrow to the right in the Fig.1) in previously agreed upon time slots. Note that the incoming bitstream B1 on the wavelength L1 is entirely converted into an electrical bitstream and thus
35   is completely prevented from further propagation along the shared medium. The other wavelength L2, which is used to transmit B2, is in this node only used for the reading

of data, which is why it is transmitted on a third
optical fibre 6 to a 1x2 coupler 3. The 1x2 coupler 3
divides L2 and further transmits L2 on a fourth optical
fibre 8 and a fifth optical fibre 9. The fifth optical
5   fibre 9 is lead to another optical/electrical converter
10. From the second converter 10, B2 is electrically
transmitted forward into the node (schematically shown
with a downward pointing arrow from the converter 10) so
that data can be read from predefinied time slots. In the
10   node, B1 is forwarded to a first 2:1 Mux 11 wherein new
data generated in the node (the upward pointing arrow to
the Mux 11) is written into B1. From the first 2:1 Mux
11, the modified bitstream B1' is now forwarded to a
first electrical/optical converter 12, which converts the
15   bitstream B1' into optical mode on the wavelength L1.
From the first electrical/optical converter 12, L2 is
transmitted on a sixth optical fibre 13 to a second WDM
coupler 14. The fourth optical fibre 8 is also provided
to the second WDM coupler 14. In the second WDM coupler
20   14, L1, carried on the sixth optical fibre 13, is brought
together with L2, carried on the fourth optical fibre,
and these two are further transmitted on a seventh
optical fibre 16 to the next downstream node.
        Fig. 3 shows an example of the table management part
25   of a node. This part may be the same regardless of if WDM
or SDM is being used. In this embodiment, two parallel
bitstreams are received and one is transmitted. Of
course, nodes that receive one or more than two
bitstreams and transmit none or more than one bitstream
30   may be used as well.
        PLL 20, 23 triggers time slot counters 18 and 25
respectively, which point to channel tables 19 and 24,
respectively. Every entrance in the channel table
corresponds to a time slot in the bitstream. When a flag
35   in any of the channel tables 19, 24 shows that the
corresponding time slot is to be read, the associated
demultiplexor 21, 22 reads data from the time slot for

further processing in the node.

Transmission of data is managed correspondingly. When the node is to transmit data, data is put into the transmission table 29 in the position that corresponds to
5   the time slot to be used for transmission. When the time slot counter 28 points to an entry in the transmission table 29 that has a flag indicating that data is to be sent in this particular time slot, the multiplexor 26 writes data into the time slot. This data is then, for
10   example, transmitted to the multiplexor 11, shown in Fig. 1. The time slot counter is trigged by a PLL 27, which preferably is synchronised to PLL 20 or 23.

Even if the receivers in Fig. 3 for the sake of clarity are shown as two separate units, they may be
15   combined into a single unit at different levels, for instance into a common control memory or a shared multiplexor for both of the received bitstreams. The units in Fig. 3 can also be obtained as integrated parts of other units, as for instance those shown in Fig. 2
20   above and Fig. 4 below.

In Fig. 4, an example of SDM with electrical trans-mitters is shown. The bitstreams B1 and B2 are carried on separate electrical carriers 30 and 31. The bitstream B1 is transmitted into a regeneration means 80, which recre-
25   ates the bitstream B1. From the regeneration means 80, the bitstream B1 is transmitted into the node. The bitstream B2 is transmitted to a distribution means 34. The bitstream B2 is transmitted from the distribution means 34 partly into the node (downward pointing arrow)
30   and partly further downstream on the carrier 37 to the next node in the network. The distribution means 34 may of course be as simple as a T-coupling, but it can also be a more advanced equipment suited to handle special problems which may arise in connection with high
35   bitstream speeds.

From the regeneration means 80, the bitstream B1 is also transmitted to a multiplexor 36, which multiplexes

write data from the node (upward arrow) with data from
the received bitstream B1. From the multiplexor 36 the
modified bitstream is further transmitted downstream on
the carrier 38.

5   In Fig. 5, an example of a shared medium with
parallel bitstreams 40a-40d transmitted on four different
wavelengths in a single optical fibre is shown. In a
schematic frame or cycle 39, containing nine time slots,
five time slots contain information. In Fig. 5, a node is

10   arranged to read data from the time slots 41a-41e from
different bitstreams, i.e. on different wavelengths. The
time slots containing data are spread out, so that,
hopefully, no data slots will reach the node at the same
time as other data slots, thus preventing the node from

15   having to receive data on different wavelengths or from
different bitstreams at the same time. This is possible
since the bitstreams are synchronised to not drift due to
dispersion or different bitclocks.

       Hence, the invention provides the possibility of

20   efficient use of the resources in a time-multiplexed
network with several parallel channels, e.g. different
wavelengths or parallel fibres, in a topology with a
shared medium. To this end, wavelength or time slot reuse
is used, which provides a possibility for the nodes to

25   reuse wavelengths and to form clusters of nodes commu-
nicating on specific wavelengths, see Fig. 6. The wave-
lengths are reused after termination (45, 46).

       Fig. 6 shows an embodiment using time slot reuse.
Three different clusters 42, 43 and 44, with several

30   nodes in each cluster, use the same bitstream or wave-
length 47 for communication within each cluster. This
means that a time slot in the bitstream 47 having been
used for communication between two nodes in the first
cluster 42 does not have to stay unused further down-

35   stream, but is reused first in the second cluster 43 and
then again in cluster 44.

       In order to prevent further propagation of the bit-

stream and the wavelength 47 downstream, and thereby
preventing disturbances in clusters situated downstream,
filters 45 and 46 are arranged between the clusters 42,
43, and 44. In each cluster 42, 43, and 44 there is a
5   special cluster representative 71, 72, and 73 for each
cluster. In this embodiment, the bitstream 47 is driven
by low power lasers, which is possible since the
distances within each cluster is relatively short. The
cluster representatives 71, 72, and 73 have access to the
10 bitstreams or wavelengths 48, 49, and 50, which are used
for long distance communication between the clusters.
        The cluster representatives 71, 72, and 73 also
function as relay stations for the communication between
the clusters. The cluster representatives 71, 72, and 73
15 are arranged to listen and transmit control information
to each other. This means that logical channels are set
up by and transmitted via the cluster representatives 71,
72, and 73.
        Since the cluster representatives 71, 72, and 73 in
20 Fig. 6 are situated most upstream in each cluster, they
generate cycles on their respective wavelengths. The
nodes within the cluster 42 use the wavelength 47 in
order to communicate, that is, to read and/or write data,
with other nodes within the cluster.
25   The cluster representatives can choose between seve-
ral different ways of transmitting information between
nodes situated in different clusters. One alternative is
that communication between nodes in different clusters is
switched via the cluster representatives. Another
30 alternative is that the cluster representatives only
handle the control signaling for the connection of a
specific DTM channel between the nodes in the different
clusters wishing to communicate with each other. The node
that initiates the communication then transmits, by way
35 of example, an inquiry to its cluster representative and
asks the cluster representative to establish the desired
channel on a suitable wavelength. The cluster representa-

tive manages this by negotiating with the other cluster
representatives, and subsequently informs the node of
which time slots are to be used for the channel.

Of course, several cluster may form super clusters,
5   and a node may be part of several clusters.

In Fig. 7, a portion of a network is schematically
shown using two parallel bitstreams, for example two
different wavelengths on one and the same optical fibre,
for communication between four nodes, 53, 59, 63, and 67.
10   The first bitstream 51 is read by the nodes 53 and 63,
and is then taken in, as a whole, into the nodes 59 and
67. The nodes 59 and 67 thus only use the bitstream 51
for the communication with the other nodes in the net-
work. Accordingly, the nodes 53 and 63 use the bitstream
15   52 for the communication with other nodes, while the
bitstream 51 is only used for the reading of data.

In Fig. 7, two bitstreams 51 and 52 are shown
arriving to a first node 53. In the node 53 the bitstream
51 is tapped for reading via the carrier 55, while the
20   bitstream 52 is taken in, as a whole, into the node 53
and there it is optically terminated. In the node 53 the
bitstream 52 is further transmitted electronically
through the node, while data generated in node 53 is
added or written into the bitstream (54), which is then
25   further transmitted optically downstream as the modified
bitstream 56. The bitstream 56 is tapped for reading via
the carrier 57 by the node 59. The bitstream 51 arrives
to node 59. The bitstream 51 is then taken in, as a
whole, into node 59, and data generated in node 59 are
30   added to the bitstream (60), which is then further trans-
mitted downstream as the modified bitstream 58. The bit-
stream 58 is tapped for reading by the node 63 via the
carrier 61. The bitstream 56 arrives to the node 63. The
bitstream 56 is then taken in, as a whole, into node 63,
35   and data generated in node 63 are added to the bitstream
(64), which is then further transmitted as the modified
bitstream 62. The bitstream 62 is tapped for reading by

the node 67 and is then further transmitted downstream.
The bitstream 58 arrives to the node 67. The bitstream 58
is then taken in, as a whole, into node 67, and data
generated in node 67 are added to the bitstream 68, which
5   is then further transmitted as the modified bitstream 66.

Fig. 8 shows a first embodiment of how the synchro-
nisation in a network with three parallel bitstreams may
be realised. In Fig. 8, a node 71, which is appointed
master node, and a bitstream 72 associated to the node
10 71, which is the trigger bitstream, is shown. The master
node adds a trigger pattern and a filling pattern to the
bitstream 72. The slave node 73 listens to the bitstream
72, synchronises its bit clock, adds a synchronisation
pattern and a filling pattern to a bitstream 74, for
15 which the node 73 is responsible, and synchronises the
start of a frame in its bitstream 74 to the start of a
frame in the bitstream 72.

The slave node 75 similarily manages the bitstream
76 for which it is responsible. Thus, all the nodes 71,
20 72, 75, 77, and 78 obtain synchronisation for all the
bitstreams 72, 74, and 76. The method is excellent for
use in the described networks. As an alternative, this
method can be used when every node uses a separate
wavelength for transmission, but read from more than one
25 wavelength.

As the frame starting points in the different bit-
streams are synchronised at every start of a frame, the
bitstreams will not drift in relation to each other.

Fig. 9 shows a cecond embodiment of how the synchro-
30 nisation in a network with three parallel bitstreams may
be realised. A master node, for instance a cluster
representative as discussed above, synchronises the
bitstream on a wavelength λ3, which is used in the first
cluster C4 of nodes. The bitstream of cluster C4 is in
35 this example used as a reference for the synchronisation
of clusters C8 and C5. The cluster C8 uses another wave-
length λ1, while the cluster C5 reuses the same wave-

length $\lambda 3$ as is used by the cluster C4 after it has been
blocked somewhere between clusters C4 and C5. The bit-
stream of cluster C8 is in this example used as a refe-
rence for the synchronisation of the cluster C6. The
5   cluster C6 uses another wavelength $\lambda 2$, and the bitstream
of cluster C6 is, in turn, used as a reference for the
synchronisation of a cluster C9, which reuses the same
wavelength $\lambda 1$ as is used by the cluster C8 after it has
been blocked somewhere between clusters C8 and C9.
10   Finally, the bitstream of cluster C5 is used in this
example as a reference for the synchronisation of the
clusters C7 and C10, wherein the cluster C7 reuses the
same wavelength $\lambda 2$ as is used by the cluster C6, after it
has been blocked somewhere between clusters C6 and C7,
15   and wherein the cluster C10 reuses the wavelength $\lambda 1$
which is used by the cluster C9, after it has been
blocked somewhere between clusters C9 and C10.

       As is understood, the invention is not limited to
the embodiments described above and shown in the
20   drawings, and alterations and modifications therof may be
made within the limits of the enclosed patent claims. Nor
is the invention limited to DTM networks, but can be used
in other types of networks that use cycles and time slots
of arbitrary sizes.

25

CLAIMS

1. Method for transferring data in time slots in at least two parallel bitstreams along one or more shared optical media between nodes in a time multiplexed network, comprising the steps of:

reading, in a node, at least one incoming of said bitstreams as a whole;

preventing further optical propagation of said incoming bitstream along the shared medium;

regenerating and transmitting the bitstream as an outgoing bitstream from the node; and

arranging at least one other of said parallel bitstreams to bypass said node without regeneration or essential modification thereof.

2. Method as claimed in claim 1, wherein said node is arranged to write data into at least one of the time slots in said at least one incoming bitstream, comprising the step of writing said data into said time slots in the outgoing bitstream in association with said regeneration.

3. Method as claimed in claim 1 or 2, wherein said shared medium comprises an optical waveguide and wherein several nodes are arranged to communicate on a first wavelength in said shared medium.

4. Method as claimed in any one of the preceding claims, wherein said network is circuit-switched.

5. Method as claimed in any one of the preceding claims, wherein said node is arranged to read time slots of said other bitstream, which thus passes said node without being essentially modified or regenerated.

6. Method as claimed in any one of the preceding claims, wherein said at least one bitstream and said

other bitstream are transferred on two different
wavelengths in an optical waveguide.

7. Method as claimed in any one of claims 1-5,
wherein each of said at least one bitstream and said
other bitstream is transferred in a respective optical
waveguide.

8. Method for transferring data via a shared medium
between nodes in a time multiplexed network according to
any one of the preceding claims, wherein:
       data are transferred in time slots in a first and a
second bitstream;
       the first and the second bitstream are transferred
using wavelength division multiplexing;
       the first and the second bitstream arrive at a node
on a first and a second wavelength via at least one
optical carrier;
       the wavelengths are separated into the first wave-
length V1, transferring the first bitstream, and the
second wavelength V2, transferring the second bitstream;
       the first wavelength V1 is converted into electronic
form and prevented from further propagation to other
nodes;
       data generated in said node is written into pre-
defined time slots in the first bitstream, resulting in a
modified bitstream;
       the modified first bitstream is converted into
optical form having the wavelength V1;
       the second wavelength V2, transferring the second
bitstream, is brought together with the first wavelength
V1, transferring the modified first bitstream, for
further propagation to other nodes.

9. Method as claimed in claim 7, wherein the
modified first bitstream is generated using a laser.

10. Method as claimed in any one of claims 1-3, wherein said bitstream is transferred using an electronic conductor and wherein further propagation of the incoming bitstream is prevented by an electronic disconnection of
5   the conductor.

11. Method as claimed in any one of claims 1-9, wherein said time multiplexing is performed using Dynamic Synchronous Transfer Mode.
10

12. Device for transferring data in time slots in at least two parallel bitstreams along one or more shared optical media between nodes in a time multiplexed network, comprising:
15   receiving means for reading at least one incoming of said bitstreams as a whole;
         filtering means for preventing further propagation of the incoming bitstream along the shared medium; and
         regenerating means for regenerating and transmitting
20   the bitstream as an outgoing bitstream;
         said device being arranged to pass at least one other of said parallel bitstreams by said node without regeneration or essential modification thereof.

25   13. Device as claimed in claim 12, comprising writing means for writing data into at least one of said time slots in the outgoing bitstream in association with said regeneration.

30   14. Device as claimed in claim 12 or 13, comprising reading means for reading time slots of said other bitstream.

15. Device as claimed in claim 12, 13, or 14,
35   wherein said shared medium is an electronic conductor.

16. Device as claimed in claim 12, 13, 14 or 15, wherein said shared medium comprises an optical waveguide in which each of said at least one bitstream and said other bitstream is transferred on a respective

5　　wavelength.

17. Device as claimed in claim 12, 13, 14, or 15, wherein said shared medium comprises at least two optical waveguides, said at least one bitstream being transferred

10　on a first optical waveguide and said other bitstream being transferred on a second optical waveguide.

18. Method for synchronising communication in time slots in a time multiplexed network, wherein data is

15　transferred in two or more parallel bitstreams, comprising the steps of:
　　　　generating a first bitstream in a first node;
　　　　providing the first bitstream with a synchronisation pattern defining a frame rate;

20　　　　generating at least one second bitstream in a second nod; and
　　　　synchronising, in said second node, the start of a frame in the second bitstream to the start of a frame in the first bitstream.

25

19. Method as claimed in claim 18, comprising the steps of:
　　　　generating a third bitstream in a third nod; and
　　　　synchronising, in said third node, the start of a

30　frame in the third bitstream to the start of a frame in the first or second bitstream.

20. Method as claimed in claim 18 or 19, comprising the step of synchronising essentially every nodes bit

35　clock to any one of said bitstreams.

21. Method as claimed in claim 18, 19 or 20, wherein the first bitstream is also provided with a filling pattern.

5   22. Method as claimed in any one of claims 18-21, wherein each bitstream is transferred on a separate wavelength.

23. Method as claimed in any one of claims 18-22, 10   wherein said time division multiplexing is performed using Dynamic Synchronous Transfer Mode.

24. System for synchronisation of communication in time slots in parallel bitstreams in a time multiplexed 15   network, comprising:
       a first node, called master node, being arranged to generate at least a first bitstream and to provide the first bitstream with a synchronisation pattern to define a frame rate;
20   a second node, called slave node, being arranged to generate at least one second bitstream and to synchronise the start of a frame in the second bitstream to the start of a frame in the first bitstream.

25   25. System as claimed in claim 24, comprising a third node being arranged to generate a third bitstream and to synchronise the start of a frame in the third bitstream to the start of a frame in the second bitstream.
30

26. System as claimed in claim 24 or 25, comprising one or more other nodes being arranged to synchronise their bit clocks in accordance with any one of said bitstreams.
35

27. System as claimed in any one of claims 24-26, wherein said network is a circuit-switched network in

which said parallel bitstreams are formed using different
wavelengths in an optical waveguide.

28. Method for using time slots in a time multi-
plexed network, comprising:
    dividing nodes in said network into clusters;
    using a first bitstream for communication between
nodes in a first cluster;
    preventing propagation of the first bitstream from
the first cluster to other clusters.

29. Method as claimed in claim 28, wherein a node
representative is appointed for each cluster, said node
representative using at least one other bitstream for
communication with other clusters.

30. Method as claimed in claim 28 or 29, wherein
further propagation of said first bitstream is prevented
by a disconnection.

31. Method as claimed in claim 28 or 29, wherein
further propagation of said first bitstream is prevented
by a passive optical filter.

32. System for using time slots for transferring
data via a shared medium in the form of an optical wave-
guide in a time multiplexed network, characterised by:
    the nodes in said network being divided into
clusters;
    a first wavelengths being allocated for
communication between nodes in a first cluster;
    and comprising means for preventing communication
transferred on said first wavelength between nodes in
said first cluster from propagating to other clusters
using the same wavelength.

33. System as claimed in claim 32, wherein a node in said first cluster, called master node, is arranged to synchronise communication on the wavelength or wavelengths being used within the cluster.

34. System as claimed in claim 32 or 33, wherein each cluster comprises a node representative which uses a second wavelength for communication with other clusters.

35. System as claimed in claim 32, 33, or 34, wherein said network is circuit-switched.

36. System as claimed in any one of claims 32-35, wherein said network is a circuit-switched wavelength division multiplexing network.

37. System as claimed in any one of claims 32-35, wherein said network is a circuit-switched space division multiplexing network.

38. System as claimed in any one of claims 32-37, wherein said means for preventing further propagation comprises a disconnection.

39. System as claimed in any one of claims 32-37, wherein said means for preventing further propagation comprises an optical filter.

1/5

Fig. 1

Fig. 2
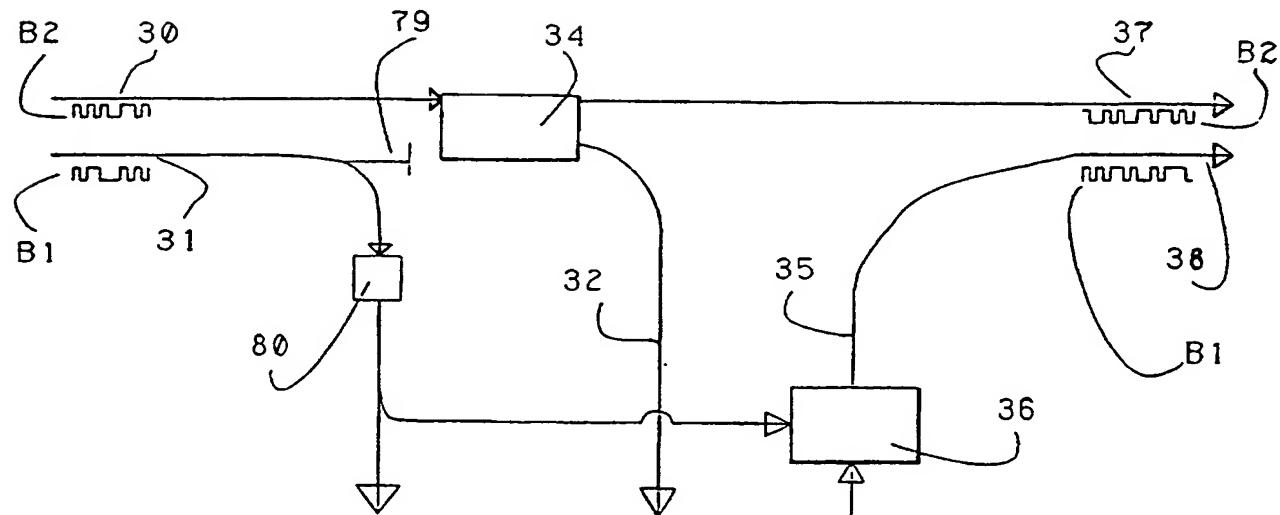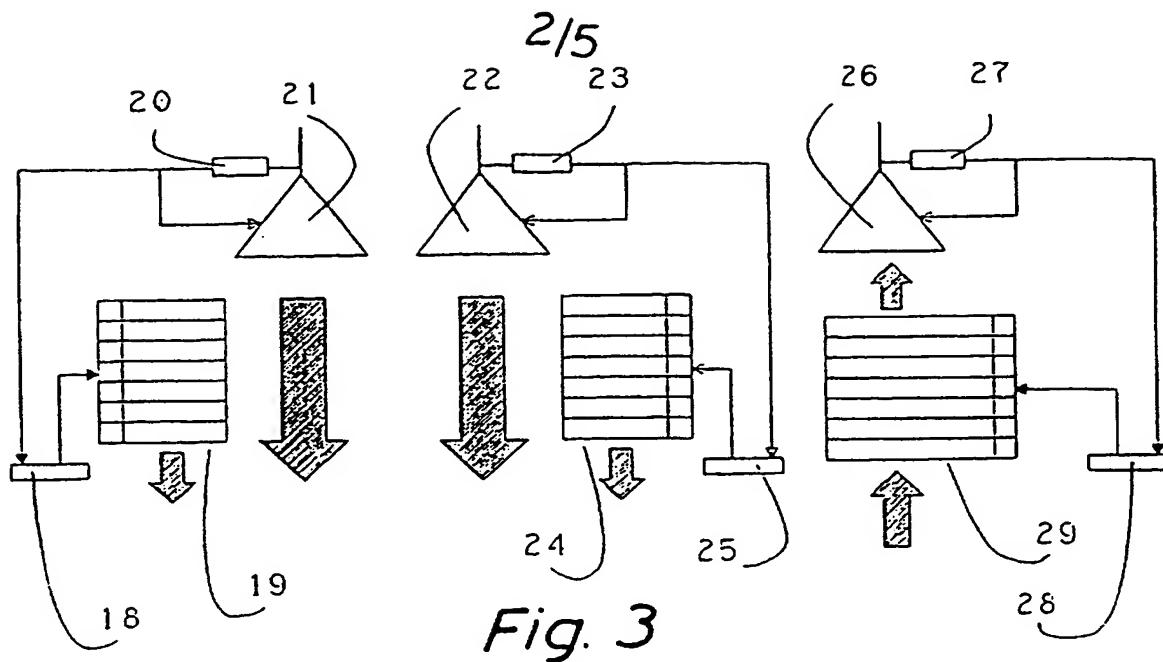
2/5

Fig. 3

Fig. 4

SUBSTITUTE SHEET
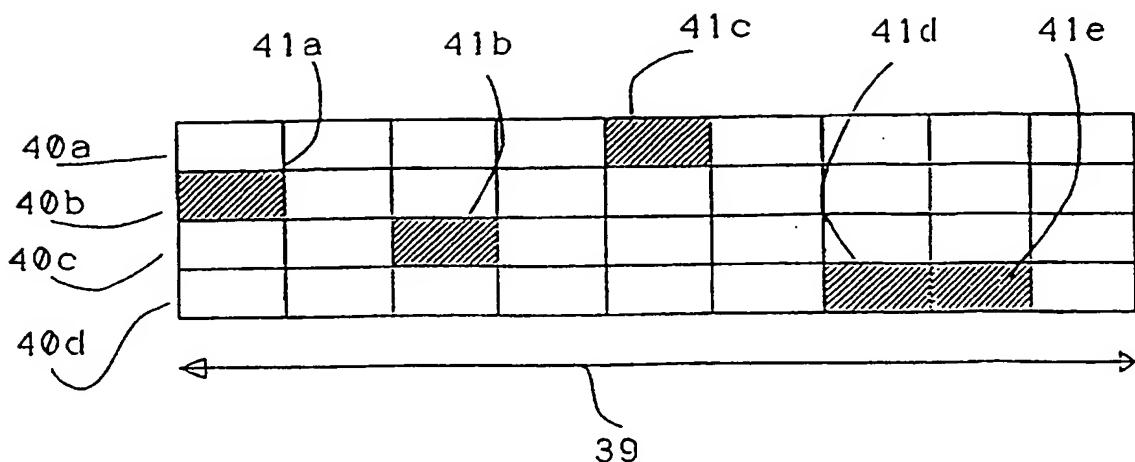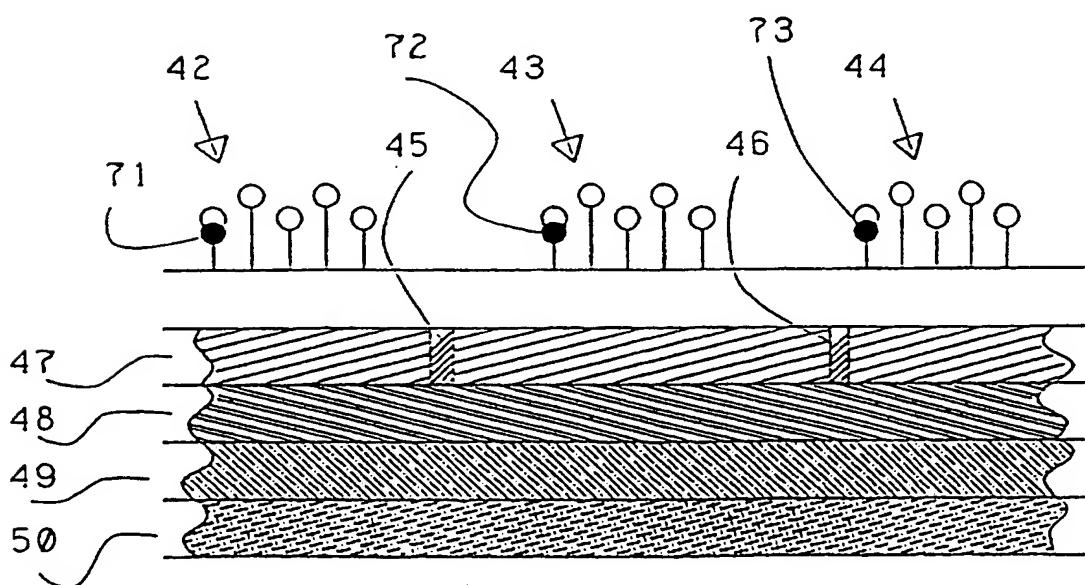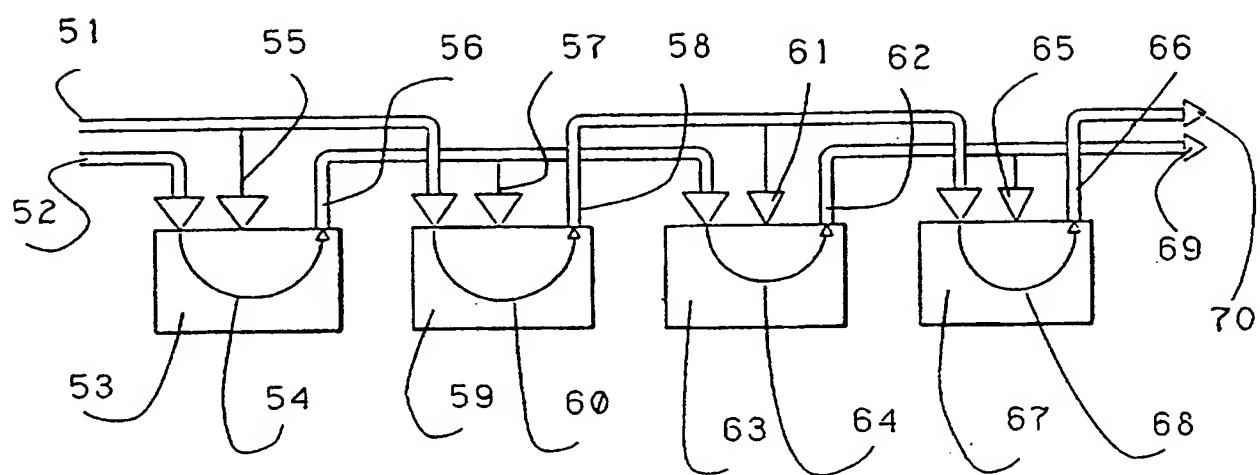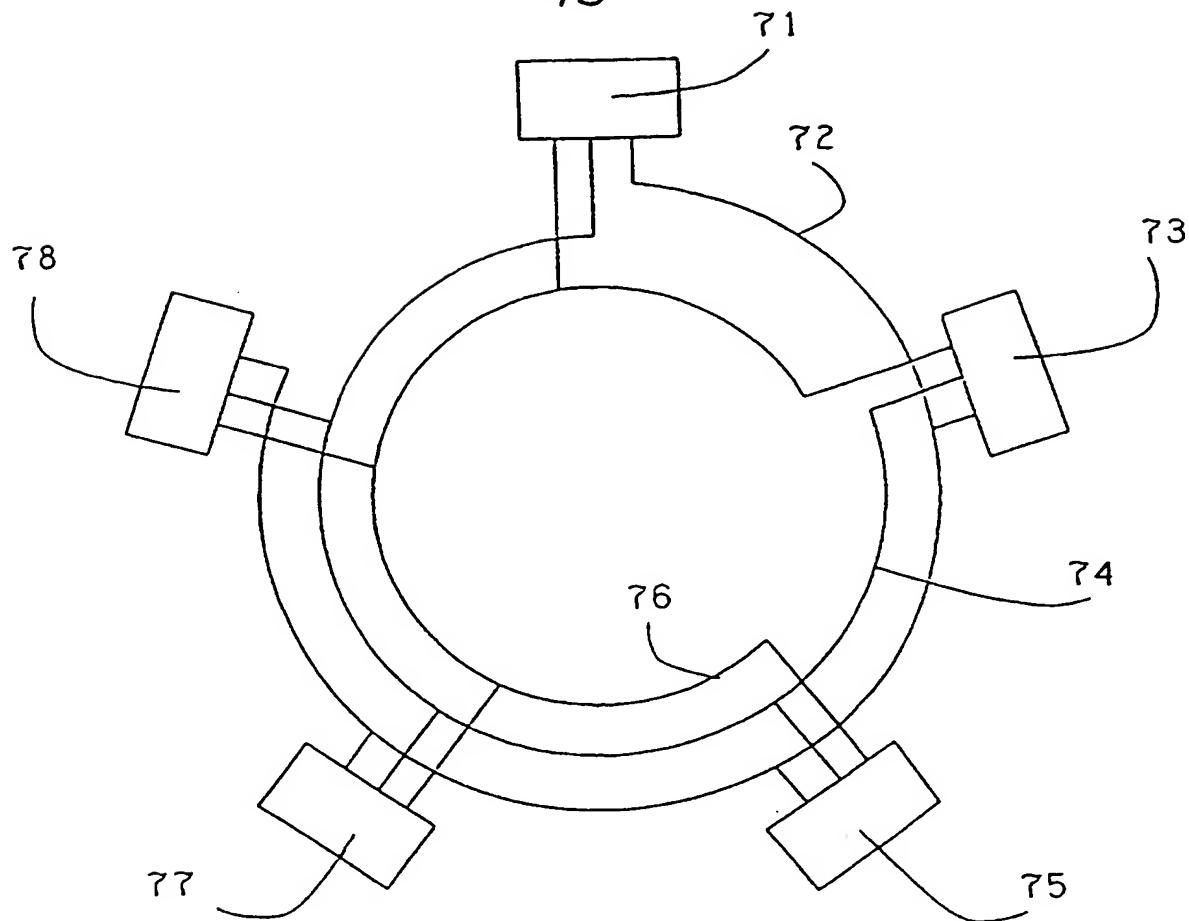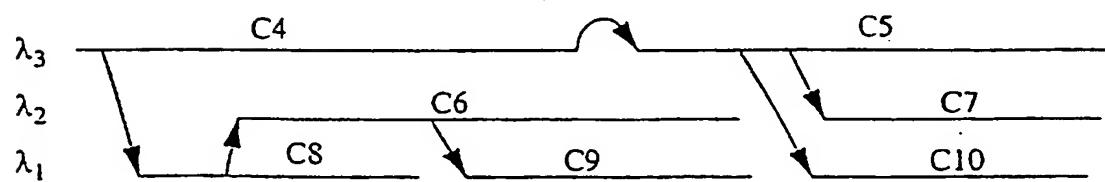
Fig. 5

Fig. 6

Fig. 7

Fig. 8

Fig. 9

INTERNATIONAL SEARCH REPORT

	International application No.
	PCT/SE 97/00523

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04L 12/43, H04L 12/407, H04L 7/08, H04J 4/00, H04J 14/00, H04J 3/06
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04J, H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0631405 A1 (FRANCE TELECOM), 28 December 1994 (28.12.94), page 4, line 27 - page 5, line 22, figure 4	1-9,11-16
Y		10,17
A		18-27
	--	
Y	EP 0457620 A2 (AMERICAN TELEPHONE AND TELEGRAPH COMPANY), 21 November 1991 (21.11.91), column 3, line 27 - column 4, line 33, figure 4	10,17
A		1-9,11-16, 28-39
	--	

X	Further documents are listed in the continuation of Box C.		X	See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 August 1997	11.08.1997

Name and mailing address of the ISA/	Authorized officer
Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Anders Ströbeck Telephone No. +46 8 782 25 00

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 97/00523

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0677935 A1 (FRANCE TELECOM), 18 October 1995 (18.10.95), column 4, line 37 - column 5, line 4; column 6, line 11 - line 22, figure 1	1-9,11-16
A		10,17
	--	
A	WO 9520847 A2 (BRITISH TELECOMMUNICATIONS PUBLIC LIMTITED COMPANY), 3 August 1995 (03.08.95), page 17, line 24 - page 18, line 15, figure 2B	1-17
	--	
A	EP 0680168 A2 (AT & T CORP.), 2 November 1995 (02.11.95), abstract	1-17
	--	
A	EP 522607 A1 (TELEFONAKTIEBOLAGET LM ERICSSON), 13 January 1993 (13.01.93), column 1, line 48 - column 2, line 21	18-27
	--	
A	EP 451426 A1 (INTERNATIONAL BUSINESS MACHINES CORPORATION), 16 October 1991 (16.10.91), page 2, line 29 - line 38	28-39
	--	
A	WO 9104622 A1 (AUSTRALIAN TELECOMMUNICATIONS CORPORATION), 4 April 1991 (04.04.91), page 4, line 21 - page 5, line 11	28-39
	--	

I. Claims 1 - 17 directed to a method for transferring data between network nodes using two parallel bitstreams, where one of the bitstreams is read by a node, changed by the node, regenerated and retransmitted.

II. Claims 18 - 27 directed to a method for synchronising two bitstreams by adding a synchronisation pattern to one of the bitstreams.

III. Claims 28 - 39 directed to a method for using the same time slot in several, disjunct clusters of nodes.

The above inventions do not have any common technical features over the prior art and thereby do not comply with the requirement of unity of invention according to PCT Rule 13.2.

Patent document cited in search report			Publication date	Patent family member(s)			Publication date
EP	0631405	A1	28/12/94	FR	2707065	A,B	30/12/94
EP	0457620	A2	21/11/91	CA	2042799	A	19/11/91
				DE	69115559	D,T	11/07/96
				JP	4230141	A	19/08/92
				US	5008881	A	16/04/91
EP	0677935	A1	18/10/95	FR	2718869	A,B	20/10/95
WO	9520847	A2	03/08/95	AU	1463395	A	15/08/95
				AU	7128694	A	13/02/95
				EP	0741934	A	13/11/96
				EP	0769916	A	02/05/97
				GB	9401488	D	00/00/00
				JP	7212347	A	11/08/95
				US	5600466	A	04/02/97
EP	0680168	A2	02/11/95	CA	2145700	A	29/10/95
				JP	7303090	A	14/11/95
EP	522607	A1	13/01/93	NONE			
EP	451426	A1	16/10/91	NONE			
WO	9104622	A1	04/04/91	AU	641688	B	30/09/93
				DE	4091624	C	25/07/96
				US	5504748	A	02/04/96